PERFORMANCE CHARACTERISTICS

OF

VARIOUS REFRIGERATION EXPANSION VALVES

A THESIS

Presented to

the Faculty of the Division of Graduate Studies

Georgia Institute of Technology

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Mechanical Engineering

by

Woodrow Wilson Lauderdale

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OF

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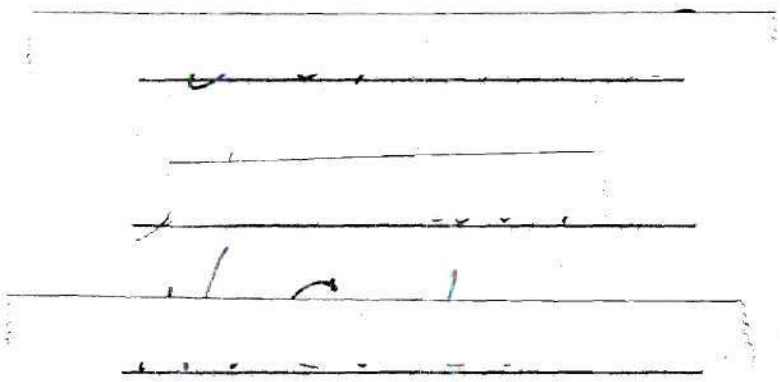
Approved:



Date approved by Chairman May 28, 1951

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INTRODUCTION

Statement of problem:

The object of the investigation was to study the performance characteristics of refrigeration expansion valves and to observe the effect which the expansion valve had on the performance of a given refrigeration unit.

A search into the history of this problem failed to reveal that any previous investigation had been made into this problem or any closely related problems.

Scope:

This investigation was made by using an Alco type TCL2F, 1/2" x 5/8" ODS thermostatic expansion valve with a 10' extension bulb and external equalization; an Alco type HK8F, 1/2" FPT high-side float valve; and an Alco type K35F, 1/2" FPT automatic expansion valve, with an evaporating pressure of 38 psig and a condensing pressure of 110 psig. The three valves shown in Figs 4a, 4b, and 4c were tested at full capacity and at two partial loads. Also a "pull down" run was made with each valve. The refrigerant used

during the investigation was freon 12. The liquid and suction line solenoids and the back pressure regulating valve, Alco type FPR15, as shown in the schematic diagram (Fig. 2), were by-passed. The cooling coil used in this investigation was of the annulus type.

DESCRIPTION OF APPARATUS

Data were obtained by the use of the Freon Refrigeration Test Unit as shown in Fig. 2. Item 19 of Fig. 2 is an Alco type K35F, 1/2" FPT automatic expansion valve; item 20 is an Alco type TCL2F, 1/2" x 5/8" ODS thermostatic expansion valve; and item 22 is an Alco type HK8F, 1/2" FPT highside float valve. These were the three expansion valves tested.

In making this investigation the liquid and suction line solenoids, the back pressure regulating valve, and the dryer shown in Fig. 2 were by-passed. Copper-constantan thermocouples were placed in the thermometer wells and connected to a Leeds and Northrup Micromax. An Aston Valve Company pressure recorder was connected to the surge drum pressure gage (item 6) shown in Fig. 2. The electrical circuit was as shown in Fig. 3 with a General Electric recording wattmeter type CP4, used as a cycling meter, wired in series with the wattmeter in Fig. 3.

The condensing unit was a Freon 12, Universal W500-FH, rated at 51,500 btu per hour at 28°F suction temperature and 80°F water temperature with a three cylinder, 3.25" x 3", 435 rpm compressor. The compressor was belt driven by a 5hp, 3 phase, 220 volt, 60 cycle electric motor.

The evaporating unit was a Potter & Rayfield Instantaneous

Water Cooling Box. This unit included 80' of 2" hard drawn type L copper pipe containing three 3/4" copper pipes for freon refrigerant. Also included were an immersion type thermostat safety switch by which the lower temperature of the water was limited, and a flapper operated safety switch to prevent icing in the coils. In addition were two constant speed centrifugal pumps, one for circulating water through the cooling coils and one to remove water from the cooling box.

The instrument section consisted of a liquid header with valving arranged to facilitate switching of expansion valves.

The temperature recording "set-up" consisted of ten copper-constantan thermocouples connected to the Leeds & Northrup Micromax with a thermocouple in each thermometer well shown in Fig. 2.

The essential items of testing equipment were as follows:

Five horsepower W500FH Universal condensing unit.

Alco type HK8F, 1/2" FPT highside float valve.

Alco type TCL2F, 1/2" x 5/8" ODS thermostatic expansion valve.

Alco type K35F, 1/2" FPT automatic expansion valve.

Potter & Rayfield instantaneous water cooling system.

Two Simmons centrifugal pumps model SJ25.

Leeds and Northrup Micromax.

G.E. Recording wattmeter type CP4.

Aston Valve Company pressure recorder.

Detroit Lubricator thermostatic motor control.

Copper-constantan thermocouples.

Scales and weighing tanks.

Stopwatch.

Hand rpm counter.

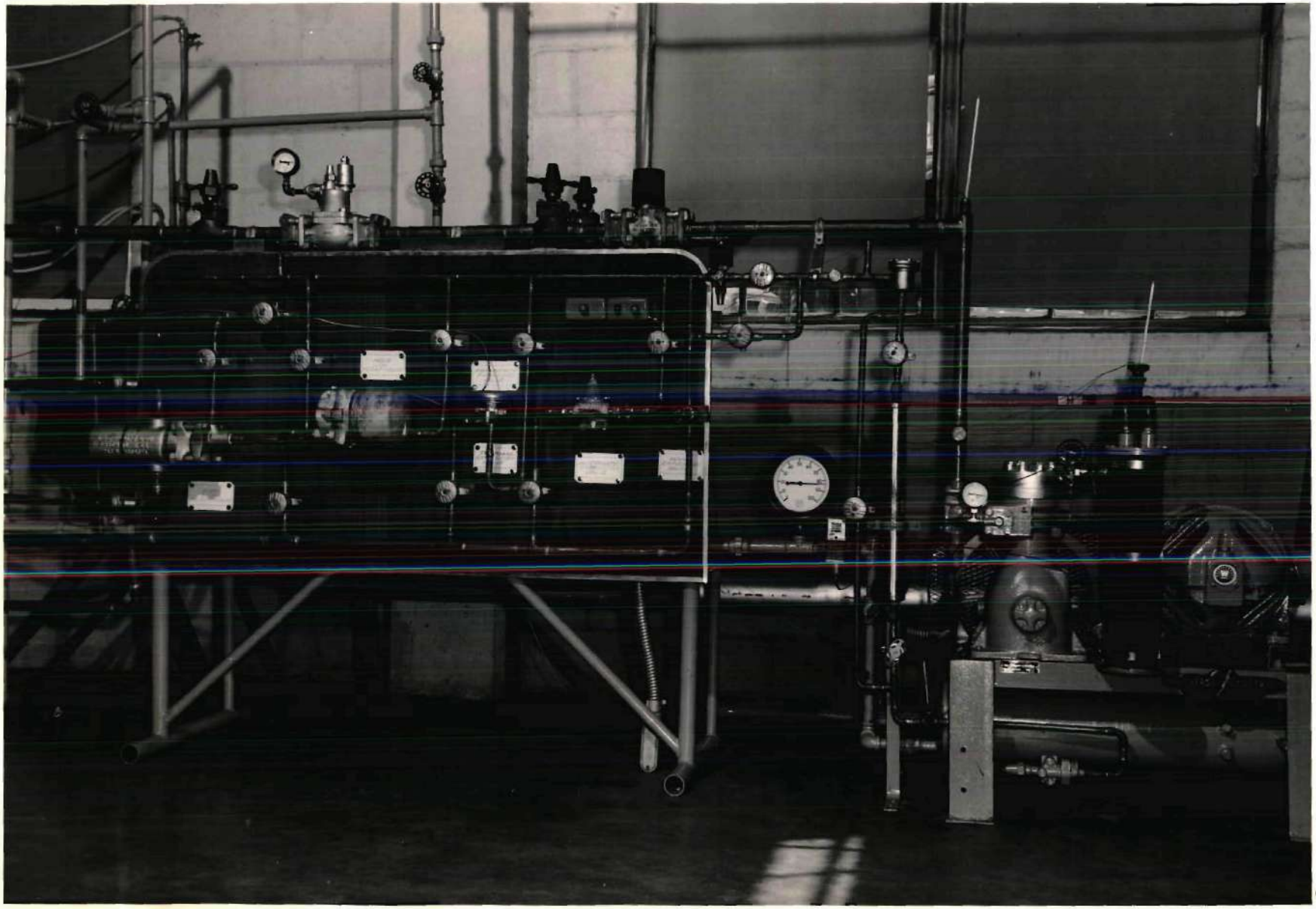


Fig. 1a

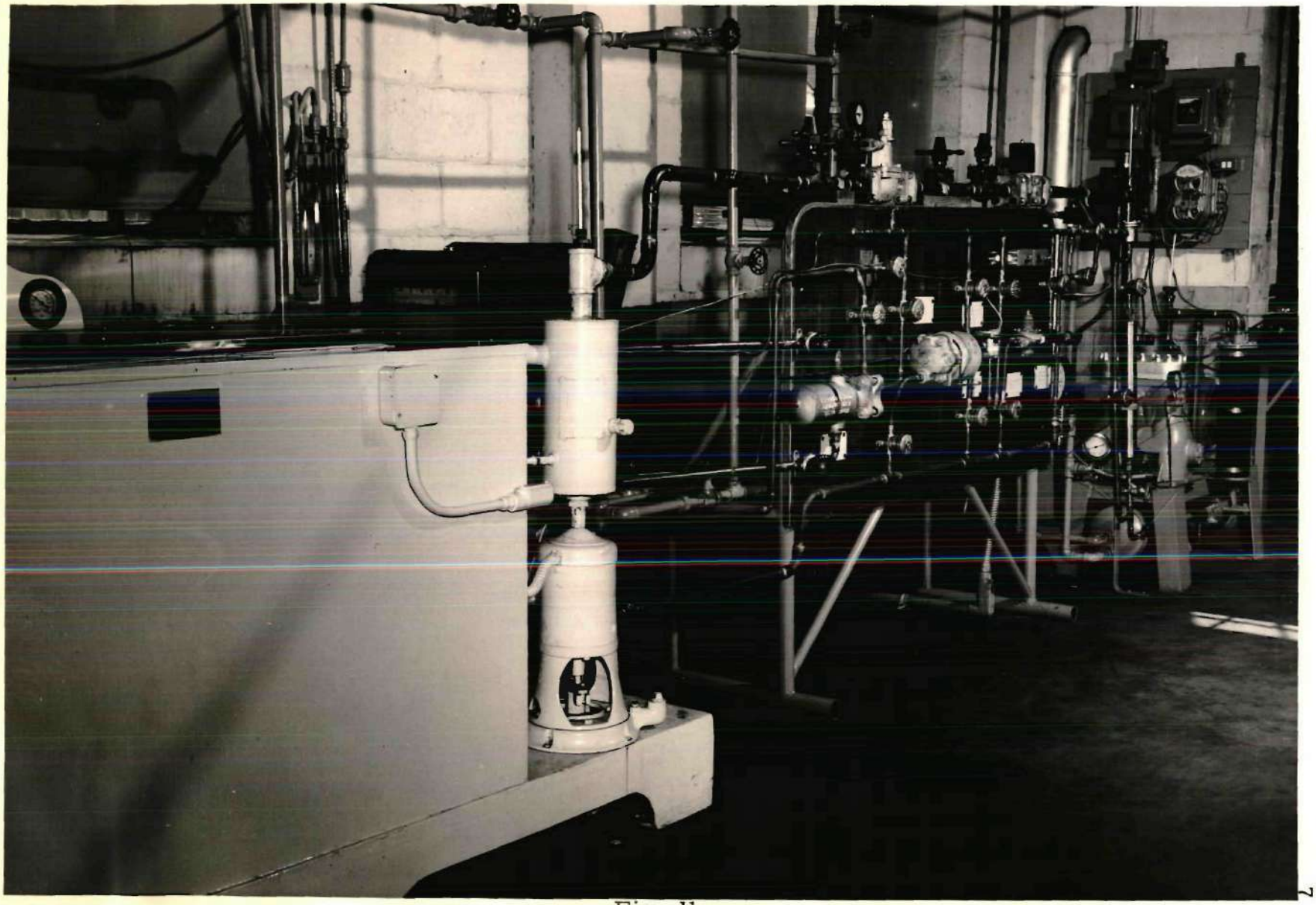
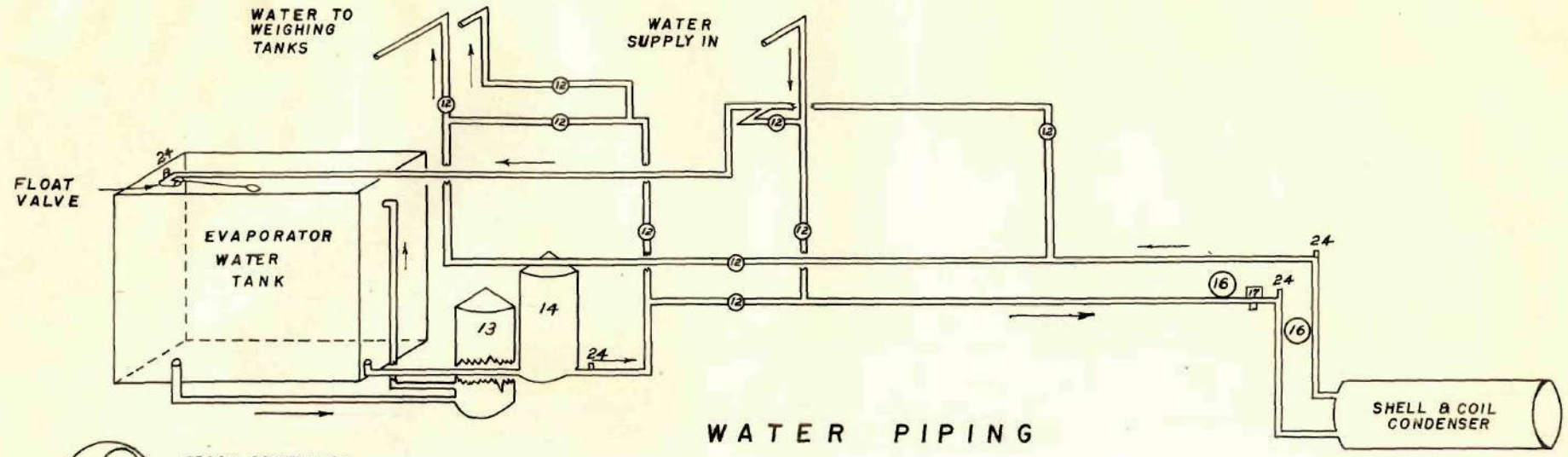
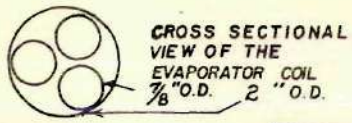
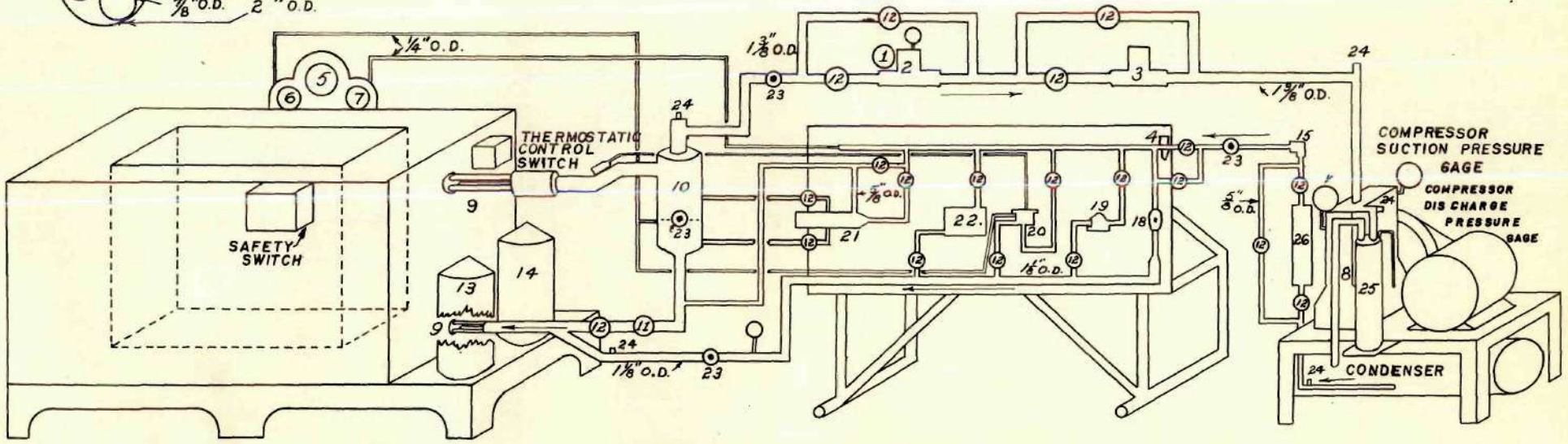


Fig. 1b



WATER PIPING





REFRIGERATION PIPING

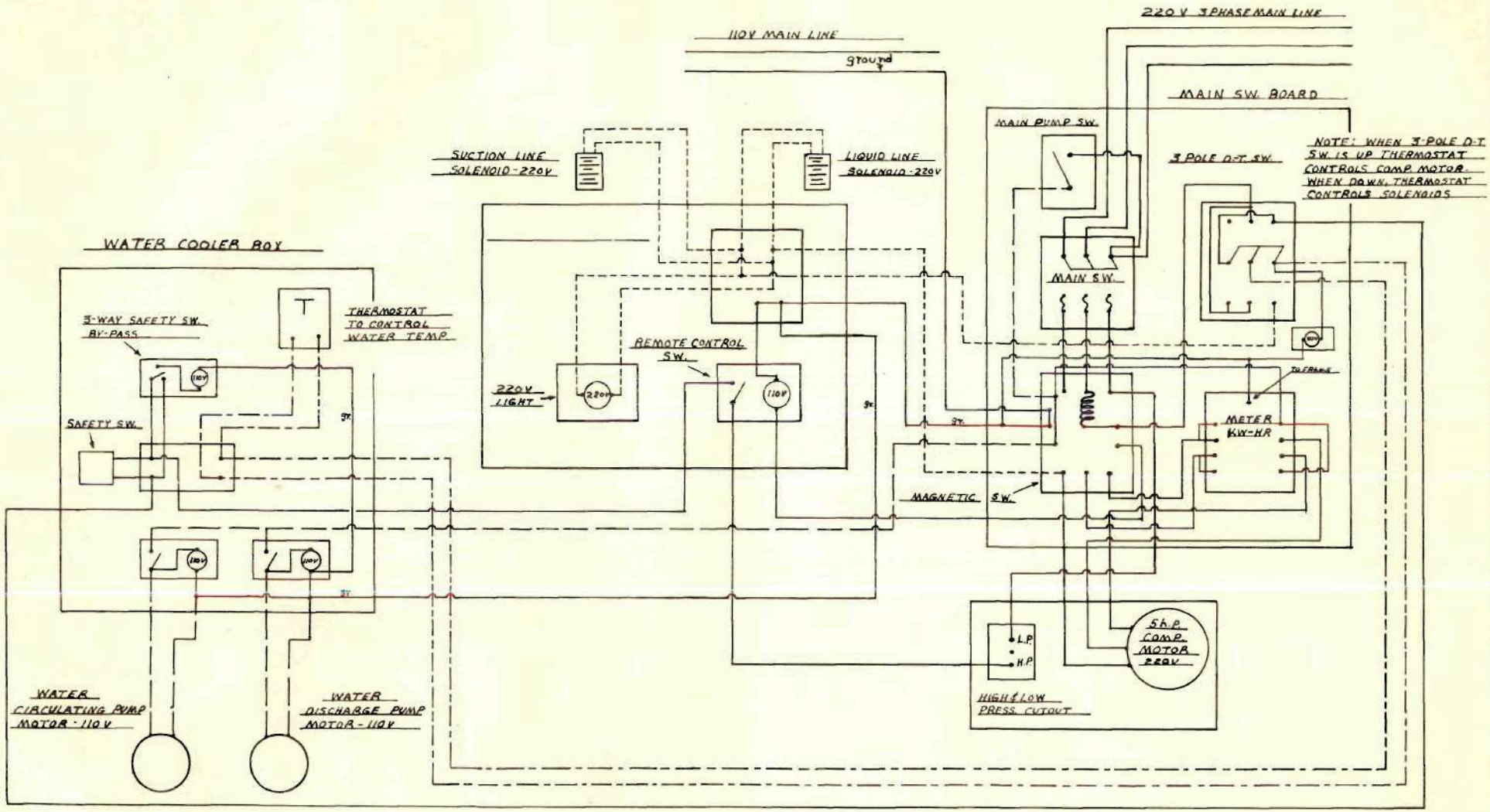
1. CONSTANT BACK PRESSURE GAGE
2. CONSTANT BACK PRESSURE REGULATOR
3. SUCTION LINE SOLENOID VALVE
4. LIQUID LINE SOLENOID VALVE
5. EVAPORATOR THERMOMETER (WATER)
6. PRESSURE IN SURGE DRUM
7. RECEIVER PRESSURE GAGE
8. COMPRESSOR
9. EVAPORATOR
10. SURGE DRUM
11. CHECK VALVE
12. SHUT OFF VALVES
13. CIRCULATING PUMP
14. DISCHARGE PUMP
15. FILTER
16. PRESSURE GAGES (WATER)
17. PRESSURE REGULATOR (WATER)
18. HAND EXPANSION VALVE
19. AUTOMATIC EXPANSION VALVE
20. THERMOSTATIC EXPANSION VALVE
21. LOW SIDE FLOAT VALVE
22. HIGH SIDE FLOAT VALVE
23. SIGHT GLASSES
24. THERMOMETER WELLS
25. OIL SEPARATOR
26. DRYER

Fig. 2

FREON REFRIGERATION TEST UNIT

SCHOOL OF MECHANICAL ENGINEERING
GEORGIA INSTITUTE OF TECHNOLOGY

DRAWN BY. ELSEVIER
TRACED BY. LAUDERDALE
SERIAL NO. 548a

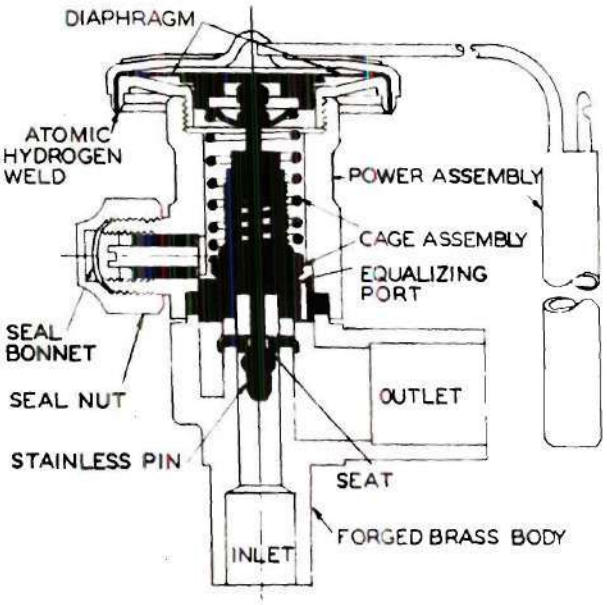


---------- SOLENOID CIRCUIT
———— 110V MOTOR CIRCUIT
— — — — THERMOSTAT CIRCUIT
———— MAIN LINE MOTOR; SAFETY SW ; & GROUND CIRCUITS

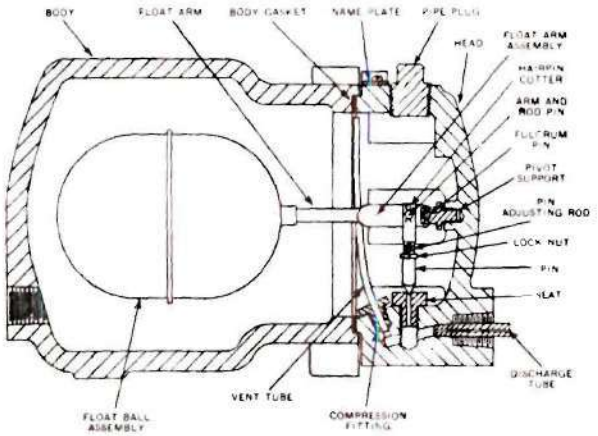
Fig. 3

ELECTRICAL DIAGRAM
F-12 REFRIGERATION TEST UNIT
MECHANICAL ENGINEERING DEPT.
GEORGIA INSTITUTE OF TECHNOLOGY

DRAWN BY: E.C. WILSON
NOT TO SCALE
Serial No 348 b

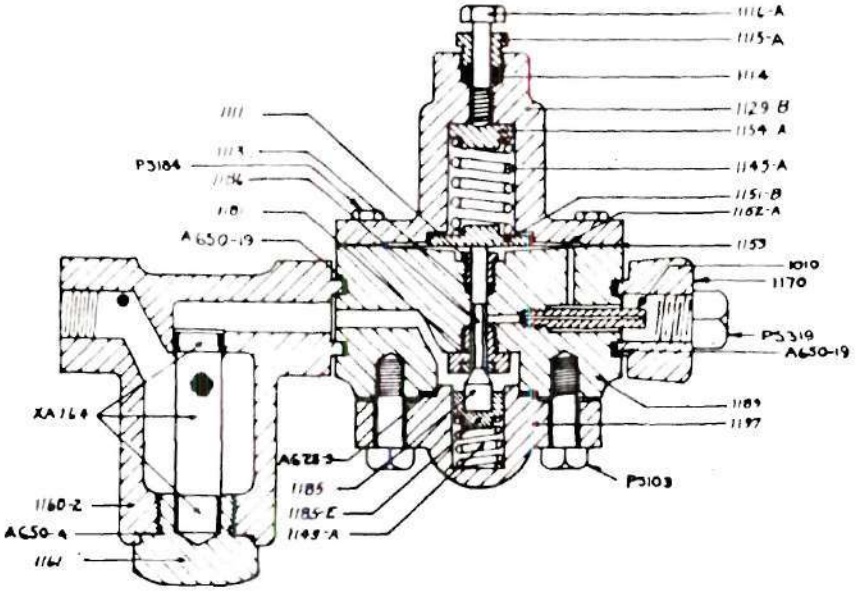


Type TCL
THERMOSTATIC EXPANSION VALVE
Fig. 4a



Type HK Float Valve

Fig. 4b
Courtesy Alco Valve Co.



Type K Valve

Fig. 4c
Courtesy Alco Valve Co.

TEST METHOD

The first valve tested was the highside float valve. The test was made so that complete data for the three runs with the highside float valve were taken before the valves were switched. A full capacity run of only one hour duration was made. It was decided that a one hour run at full capacity would give reliable results after stable conditions were established. To be sure of steady conditions the unit was run for one and one half to two hours before data were taken.

In order to maintain as nearly as possible 80°F water entering the cooling box, hot water was mixed with the campus main water. This temperature was subject to change depending upon the surges in the water main pressure. However, the flow rate of evaporator water was not affected by pressure surges. The water valve on the discharge side of the constant speed centrifugal pump was set to give a flow of 2460 pounds of water per hour, and the recorded data were observed at 5 minute intervals. After the completion of the one hour run the flow of the water was reduced to approximately eighty percent of full capacity and the temperature control in the cooling box was set for a minimum coil temperature of 50°F with a 5° range between "cut-out" and "cut-in" temperatures. The unit was allowed to cycle several times to see if the "cut-out" switch was functioning properly. Then the starting time was marked on the micromax and the cycling meter.

A part load run of six hours duration was made. The suction pressure was recorded as shown in Fig. 8 so that any variation in pressure of the system could be observed.

The weight of the water was determined by periodically observing the time required for 100 pounds of water to flow into the weighing tanks. The electrical input was determined by counting the rpm of the wattmeter disc and then multiplying by the product of the meter constant, 1.2, and the actual running time. The speed of the compressor was determined with a hand rpm counter.

The micromax was checked against the thermometers used in the full capacity run and the temperature recorded by the micromax was observed to be 1.5°F higher than the thermometer measuring the temperature of the water leaving the evaporator. The other micromax recordings checked with the thermometer readings. Therefore a 1.5° correction was made on the temperature difference of the water in and out of the cooling box.

This same procedure was followed when testing each of the other valves.

A "pull down" run on each valve was made by filling the cooling box of 430 pounds capacity with 85°F water and starting the compressor and observing the drop in temperature at five minute intervals to a temperature of 45.5°F. Two "pull down" runs on each valve were made and the results were the same with each run.

DISCUSSION

The test on the highside float valve gave a refrigerating capacity of 63, 600 Btu/hr with a coefficient of performance of 4.7. A decrease in running time caused a straight line variation of refrigeration effect. The apparent increase in the coefficient of performance as the load decreased was probably caused by the increase in the receiver temperature. The "pull down" test with the highside float valve showed a cooling rate of 16, 980 Btu in 23.7 minutes or 42, 143 Btu/hr.

For the thermostatic expansion valve the refrigerating capacity was 61, 501 Btu/hr with a coefficient of performance of 4.65. The coefficient of performance appeared to increase with a decrease in load. The "pull down" test with this valve was 16, 980 Btu in 22.93 minutes or 44, 435 Btu/hr.

The automatic expansion valve gave a refrigerating capacity of 64, 155 Btu/hr with a coefficient of performance of 4.84. The "pull down" time was 25 minutes for a load of 16, 980 Btu or a cooling rate of 40, 752 Btu/hr.

Theoretically the plot of refrigerating effect versus percent running time (ratio of actual compressor running time to total test time) would be a straight line, and it is shown on the plot (Fig. 5) that for each of the valves the refrigerating effect was a straight

line function of the running time.

It became apparent from the data as recorded in tables I, II, III, that the thermostatic valve gave the best state point for the freon leaving the evaporator; that is, the superheat was lower, thereby increasing the volumetric efficiency of the compressor.

Measurements were not made to study the heat transfer in the cooling coils by the use of these valves, but the heat transfer should be better when the coils are flowing full of liquid freon, due to the wetting of the coil surfaces. Therefore, if the freon is leaving the evaporator with a lower superheat with the use of the thermostatic valve, the heat transfer should be better because of the flooded condition.

Also, with the thermostatic expansion valve giving a more positive control of the state point of the refrigerant leaving the evaporator, the coils can be designed for the load to be handled without having to include a large factor of safety for the heat transfer surface. The thermostatic expansion valve can be used in either "top-feed" or "bottom-feed" evaporators.

Fig. 11, a wattmeter recording of the compressor cycling, shows a large although momentary increase in power on starting. Omission of this starting power caused a slight deviation from a zero slope as is shown in Fig. 7. A wattmeter which records small total quantities would give a more accurate result.

The temperature recording would show more exact analysis of

the temperature variation if a continuous type recorder were used instead of the point type with an eight minute cycle. For a good analysis the state point of the freon needs to be considered only when the compressor is running. From the plot of the temperature superimposed on an "on-off" diagram, chart I, an average temperature of the freon during running was obtained.

A test run at 10% intervals of capacity would probably give more conclusive evidence of the performance characteristics of these expansion valves, but to make a test of this type it would be necessary for the water to the evaporator to be so controlled that the temperature would remain constant regardless of the pressure surges in the main. As is seen from the data, table IId, the temperature of the water entering the evaporator varied as much as 20°F on some of the cycling runs. This variation in temperature, although averaging over the six hour period to give an accurate refrigeration effect, made it almost impossible to predict the percent rated capacity being obtained until the run was over and the data removed from the record rolls.

Also, during this investigation it became evident that the heat transfer during the cycling runs would offer a good field of investigation, if the apparatus included a flow meter in the liquid line and several thermocouples placed at intervals along the coils so that the mean temperatures and velocities could be determined.

It appears that in the cycling runs the heat flow is always in a transient state.

Although the data here showed no appreciable difference in the effect of the expansion valves on a given refrigeration unit, an investigation wherein the flow of the refrigerant was known might prove of interest.

The charts in Appendix III show the cycling of the compressor and the temperature of the freon relative to the cycling. The on and off times were taken from the recording wattmeter chart as shown in Fig. 11. The shaded areas on the charts indicate running time. From these charts the tabulated data sheets were marked with asterisks to indicate the running temperature at the various stations.

CONCLUSIONS

1. The differences in the capacities of the three valves were within the range of experimental variation; therefore, it was concluded that the type of expansion valve has little or no effect on the refrigeration capacity of a given refrigeration unit. This result may be explained by a study of the construction of the valves shown in Figs. (4a, 4b, 4c). The highside float valve and the automatic expansion valve have the same type of capillary tube as an outlet to the evaporator; therefore, both expansions are alike and the type name is only a metering or control device for the flow of the refrigerant. The valve needle in the thermostatic expansion valve does control the expansion by the clearance around the valve seat. The diameter of the passage of the thermostatic valve tested must have been such as to give the same expansion as the other valves.

2. The thermostatic expansion valve has a faster rate of cooling on the "pull-down" than the other valves.

3. The thermostatic expansion valve gave a more positive control of the state point of the freon leaving the evaporator.

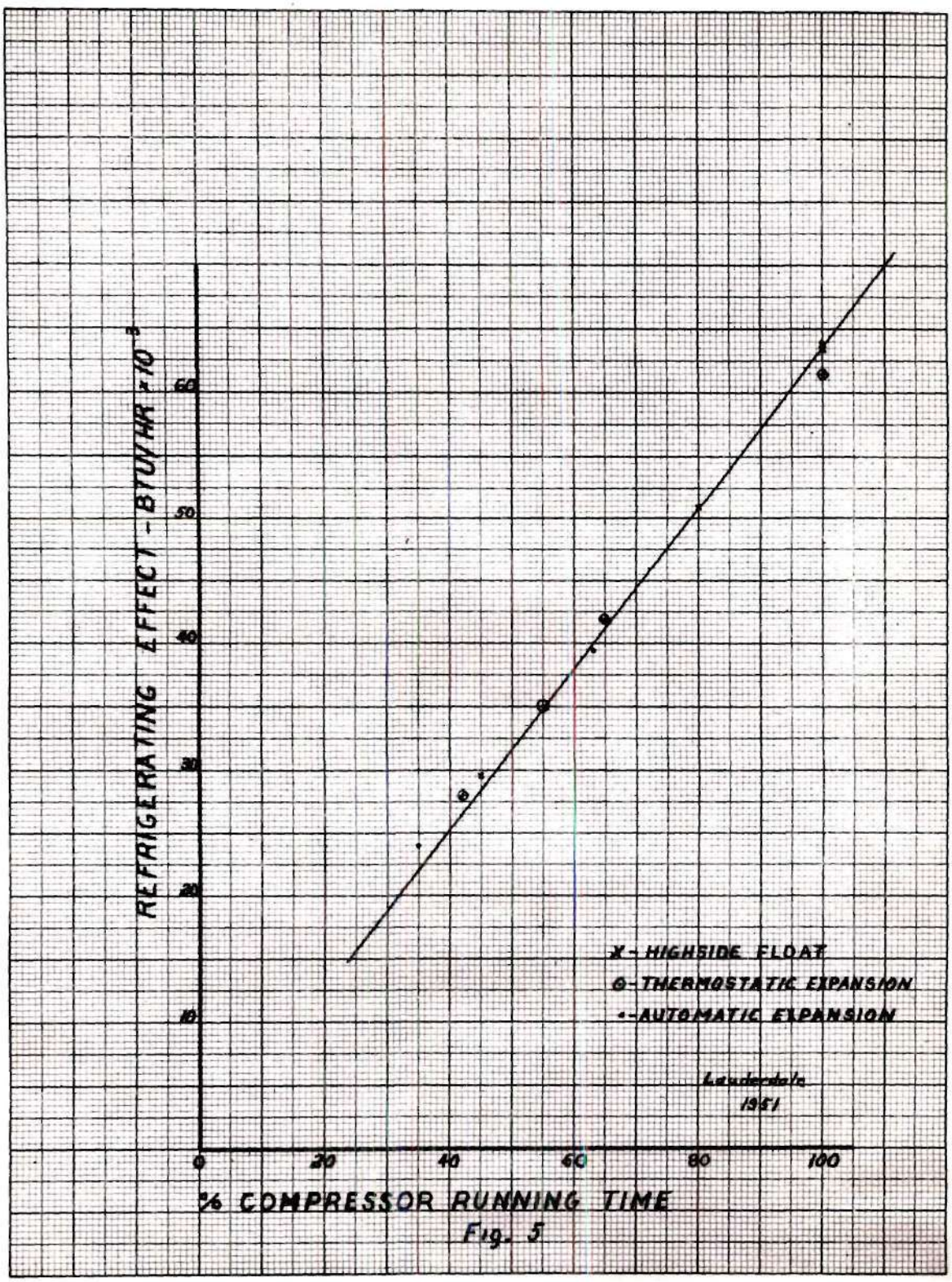

REFRIGERATING EFFECT - BTU/HR x 10⁻³
60
50
40
30
20
10
0
20
40
60
80
100
% COMPRESSOR RUNNING TIME
X - HIGHSIDE FLOAT
⊙ - THERMOSTATIC EXPANSION
• - AUTOMATIC EXPANSION
Lauderdale
1951

Fig. 5

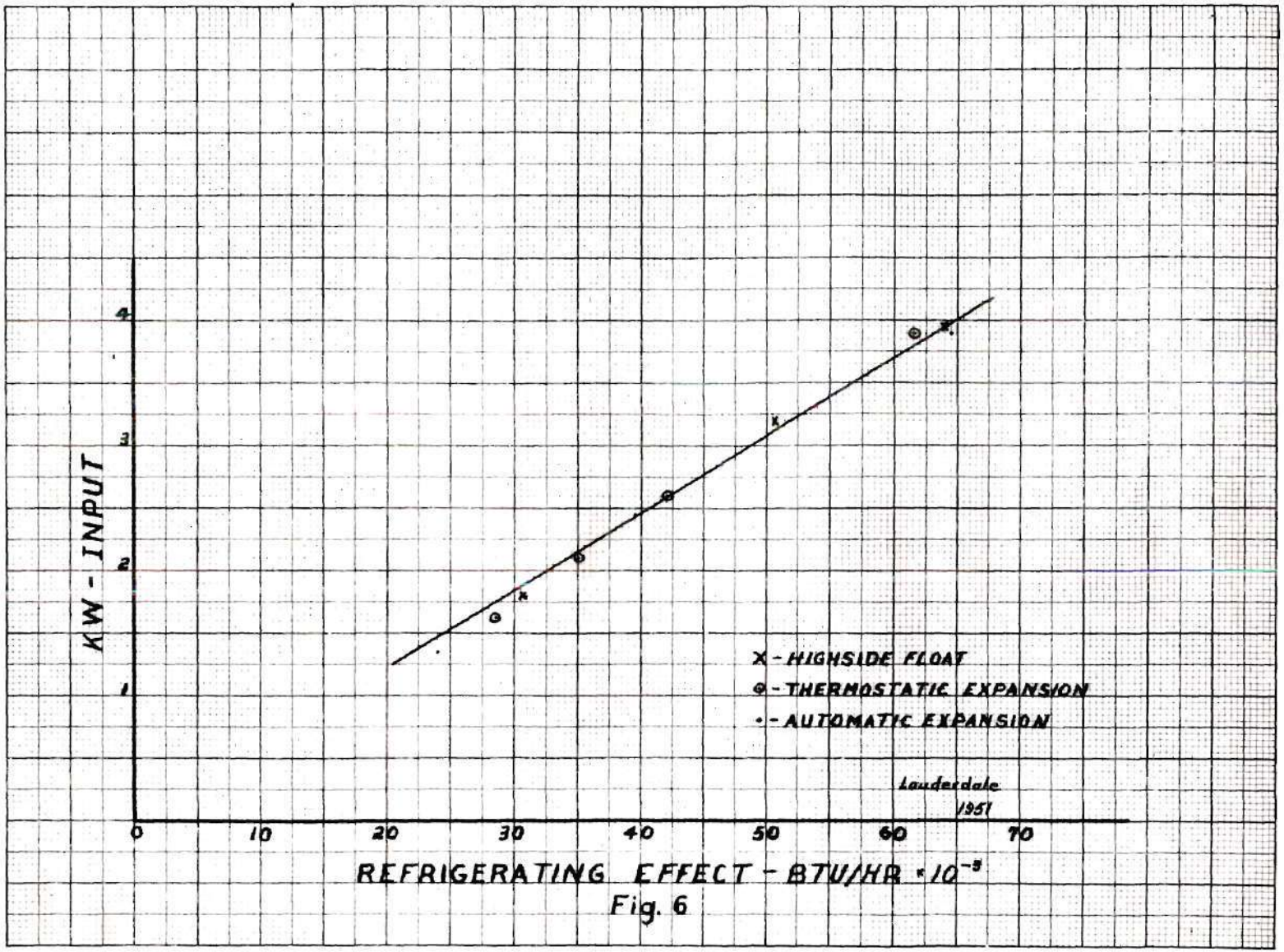

KW - INPUT
4
3
2
1
0
10
20
30
40
50
60
70
X - HIGHSIDE FLOAT
⊙ - THERMOSTATIC EXPANSION
• - AUTOMATIC EXPANSION
Lauderdale
1951
REFRIGERATING EFFECT - BTU/HR × 10⁻³

Fig. 6

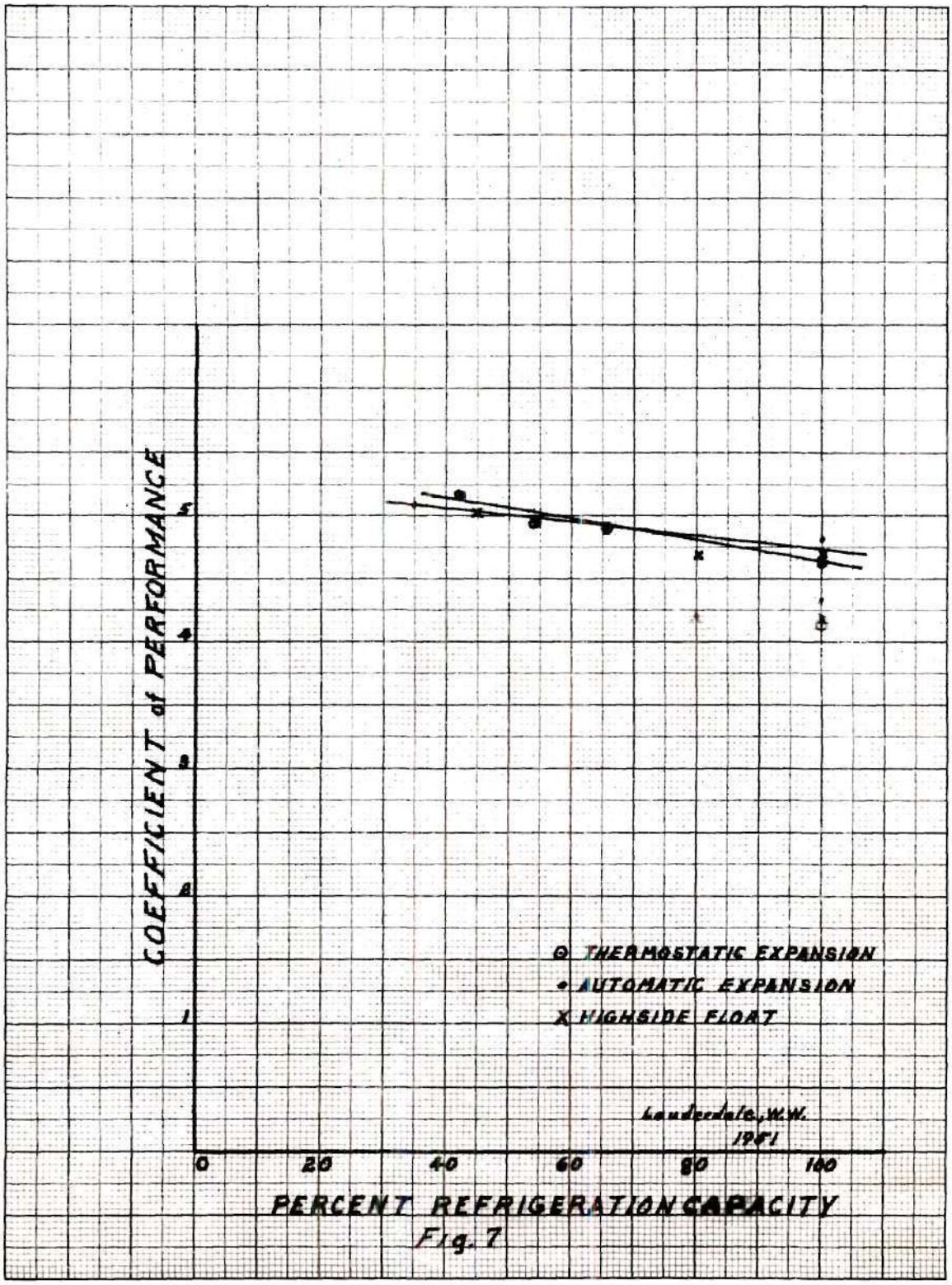

COEFFICIENT of PERFORMANCE
5
4
3
2
1
0
20
40
60
80
100
PERCENT REFRIGERATION CAPACITY
⊙ THERMOSTATIC EXPANSION
• AUTOMATIC EXPANSION
X HIGHSIDE FLOAT
Lauderdale, W.W.
1951

Fig. 7

Table I

COMPARISON OF "PULL-DOWN"

TYPE OF VALVE	LOAD IN BTU	TIME IN MINUTES	POWER REQUIRED
Highside Float	16,980	23.7	1.77KW
Thermostatic Expansion	16,980	22.92	1.57KW
Automatic Expansion	16,980	25.00	1.77KW

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APPENDIX I

Table IIa

HIGHSIDE FLOAT VALVE
1-26-51
Full Capacity

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
45.2	52.2	80.5	54.0	54.0
45.0	53.0	80.5	54.0	54.0
45.0	52.8	80.0	54.0	54.0
45.0	53.0	80.5	54.1	54.0
45.0	53.0	80.5	54.0	54.0
45.0	53.5	80.5	54.0	54.0
44.8	53.2	80.0	54.5	54.0
45.0	53.1	80.0	54.2	54.0
44.8	53.1	80.5	54.2	54.0
45.0	53.2	80.5	54.5	54.0
45.1	53.8	80.5	55.0	54.0
45.0	53.5	81.0	55.0	54.0
44.99	53.12	80.42	54.29	54.00

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
54.0	131.0	49.0	91.0	83.5
54.5	130.0	49.5	90.5	83.0
54.5	130.5	49.0	91.5	83.5
55.0	130.5	49.0	91.0	83.0
55.0	131.0	49.5	91.5	83.5
55.0	131.0	49.5	91.0	83.0
55.1	131.0	49.5	90.5	82.5
55.0	131.0	50.0	90.5	82.5
55.0	131.0	49.5	90.5	83.0
55.0	131.0	50.0	91.0	83.0
55.5	131.0	50.0	91.0	83.0
55.5	131.5	49.7	91.0	82.5
54.93	130.88	49.52	90.91	83.0

Receiver Pressure psig	Suction Pressure psig	Discharge Pressure psig	Water Cooled #/hr	Cond Water #/hr	Comp Speed rpm	Watt Meter rpm
110	38	125	2460	1802	446	55

Table IIb

HIGHSIDE FLOAT VALVE
1-26-51
80% Running Time

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
47*	50*	83	57	57
64*	47*	81	59	59
47*	50*	83	56	56
48*	61*	73	59	58
46*	49*	83	57	57
57	62*	73	59	58
46*	50*	83	56	56
56	62*	72	59	58
47*	50*	83	57	57
46	51*	83	56	56
47*	62*	73	59	58
47*	50*	83	57	57
47*	51*	83	56	56
46*	58*	73	57	56
47*	49*	83	57	57
46	50	83	55	55
56*	62*	73	59	58
46*	50*	84	57	57
46	51	83	55	55
62*	63*	73	59	58
46*	59*	83	56	56
46	50	83	54	54
61*	62*	71	59	58
46*	49*	83	56	56
46	50*	83	55	55
60*	62*	72	59	58
45*	49*	83	56	56
45*	50*	83	55	55
62*	63*	72	59	58
46*	50*	84	56	56
46*	50*	83	55	55
49	50*	83	58	58
46*	50*	83	56	56
50	61	72	55	57
46*	49*	83	58	56
46*	50*	84	56	55
62*	50*	82	58	58

Table IIb - cont.

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
46*	50*	84	57	56
47*	60*	73	55	57
46*	50*	84	60	57
46*	50*	84	55	55
63*	64	78	58	60
46*	50*	84		
49.9	53.62	80.04	56.95	56.66
50.1*	53.42*			

* Temperature of freon when compressor is running.

Table IIc

HIGHSIDE FLOAT VALVE
1-26-51
80% Running Time

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
58	123	54	93	87*
53*	127*	54	93	79*
54*	128*	54	93	87*
57*	126*	56	93	86*
53*	128*	53	92	87*
56*	126*	55	93	86
54	127	54	93	87*
56*	127*	54	93	87
54*	127*	54	93	88*
54*	127*	54	92	87
56*	126*	55	92	85*
54*	127*	54	93	87*
54*	127*	54	92	87*
63*	123*	55	90	85*
54	127	54	93	86*
54*	127*	54	93	86
56*	127*	55	93	86*
54	127	54	93	88*
54*	125*	53	93	86
53*	126*	54	93	81*
54	126	54	92	87*
54*	125*	53	92	86
52*	126*	54	92	81*
53*	127*	53	92	86*
54*	127*	53	92	86
54*	125*	54	92	84*
53*	127*	53	92	87*
54	125	53	92	86*
54*	126*	54	92	81*
54*	127*	53	93	87*
54	119	54	92	86*
54*	127*	55	93	84
53*	127*	53	92	86*
47*	126*	56	92	86
53*	127*	54	92	87*
63*	120*	54	92	86*
53*	127*	54	93	75*

Table IIc - cont.

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
54*	127*	54	92	87*
60	126*	56	94	86*
54*	127*	55	93	88*
57*	124*	54	93	86*
54*	127*	56	94	88*
54.8	126	54.11	92.54	85.42
54.4*	126.23*			85.45*

* Temperature of freon when compressor is running.

Table IId

HIGHSIDE FLOAT VALVE
1-27-51
45% Running Time

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
46*	58*	70	60	59
59	58*	70	59	59
51*	58*	68	59	58
51*	58*	68	58	57
44*	59	68	58	58
54	47	74	57	58
62	58*	84	57	57
59*	60*	83	59	59
57*	59*	72	59	58
58*	59*	71	58	57
44*	56*	68	59	59
48*	47	70	58	57
61	61	86	58	58
45*	58*	69	60	59
45*	47*	72	58	58
46*	47	78	57	57
62	62	86	56	56
61	61	69	59	58
58	59*	76	59	59
44*	52*	70	59	58
47*	48*	75	58	57
64	60	90	58	57
60	60*	87	59	58
45*	47*	72	60	59
63	53	91	57	57
59	61*	88	59	59
44*	47*	71	60	59
59*	46	82	56	56
63	61	88	58	58
45*	46*	70	59	58
58*	47*	76	56	56
59*	61	89	58	57
44*	46*	71	59	58
58	48*	86	56	56
60	61	88	58	58
45*	47*	72	60	59
63*	49*	91	57	56

Table IId - cont.

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
59	60	71	59	59
45*	47*	90	59	58
62	62	86	57	57
52*	59	72	60	59
48*	62*	73	59	58
49.69*	53.65*	79.84	58.36	57.84
53.83	54.65			

* Temperature of freon when compressor is running.

Table IIe

HIGHSIDE FLOAT VALVE
1-27-51
45% Running Time

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
51*	126*	54	94	83
51	125*	53	93	89*
58	122*	52	93	89*
58	122	55	92	89*
62	112	53	91	71
62*	116	54	92	73*
51*	123*	54	93	82*
52*	126*	54	94	89*
53*	126*	54	93	89*
61	122*	55	95	89*
64	110	57	93	84
58	121	56	93	79
52*	125*	54	93	90*
64*	120*	56	95	90*
63	115	57	93	86*
60	120	56	93	76
54*	122	54	93	80
52*	127*	55	93	83*
56*	125*	54	93	90*
64	116*	57	94	84*
60	122	57	93	78
52*	128*	56	96	89*
60*	125*	57	95	91*
63	118*	59	95	74
52*	129*	57	94	84
60*	125*	56	95	90*
62	118	59	94	83*
56	127	55	93	72
52*	126*	55	94	90*
53*	125*	57	95	80*
63	116	56	93	71
53*	126*	55	93	71
53*	125*	56	93	89*
65	116	56	95	80
55*	127*	56	93	71
52*	128*	57	94	91*
56	118	56	96	86*

Table IIe - cont.

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
66*	121*	55	93	87*
62	121*	58	93	74
68	114	55	93	70
53*	128*	56	94	77
54*	128*	58	94	83*
54.86*	124.55*	55.69	93.63	86.84*
57.52	122.19			82.52

* Temperature of freon when compressor is running.

Table IIf

HIGHSIDE FLOAT VALVE
1-26-51
80% Running Time

Receiver Pressure psig	Suction Pressure psig	Discharge Pressure psig	Water Cooled #/hr	Cond Water #/hr	Comp Speed rpm	Watt Meter rpm
110	38	125	1750	1760	446	55

1-27-51
45% Running Time

Receiver Pressure psig	Suction Pressure psig	Discharge Pressure psig	Water Cooled #/hr	Cond Water #/hr	Comp Speed rpm	Watt Meter rpm
110	38	126	1065	1720	448	55

Table IIg HIGHSIDE FLOAT VALVE

COMPRESSOR RUNNING TIME

1-26-51		1-27-51	
On	Off	On	Off
Minutes		Minutes	
4.50	3.00	5.89	4.91
12.51	3.00	1.08	2.55
15.68	3.50	2.94	5.10
12.67	3.00	3.73	5.30
13.34	3.34	3.93	5.89
16.68	3.67	3.54	5.50
20.85	8.01	4.12	4.71
18.68	4.67	4.12	4.91
19.02	4.34	2.94	6.09
20.85	6.84	3.14	6.09
22.02	4.00	3.93	5.89
21.52	3.84	3.93	5.89
14.18	5.34	4.32	5.89
20.68	4.50	4.71	6.28
13.52	3.50	2.94	4.32
17.35	3.67	3.93	5.89
14.51	3.50	4.32	5.10
9.51		4.71	5.30
		5.10	5.82
288.06	71.72	5.10	6.09
		5.30	6.28
		5.30	5.50
Total time 359.78 minutes		5.10	5.70
		5.30	5.82
		5.30	5.82
		5.30	6.28
		5.70	6.28
		5.70	6.28
		6.50	6.48
		5.90	6.87
		5.70	7.07
		5.70	6.68
		5.30	7.46
		5.90	7.07
		.98	
		156.40	197.11

Total time 353.51 minutes

Table IIIa THERMOSTATIC EXPANSION VALVE
3-19-51
Full Capacity

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
45.5	50.0	80.5	52.0	54.0
45.5	50.5	80.0	52.0	54.0
45.5	50.5	78.0	52.0	52.0
43.0	46.6	78.0	50.0	52.0
43.0	46.0	82.0	52.0	52.0
45.0	49.0	81.0	53.0	53.0
45.5	50.0	82.0	52.5	54.0
46.0	50.5	81.0	53.0	54.5
45.5	50.5	80.0	52.5	54.0
44.94	49.23	80.28	52.11	53.28

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
51.5	126	56.0	90.0	84.5
52.0	125	55.0	91.0	83.0
52.0	125	55.0	90.0	83.0
47.0	123	54.0	89.0	83.0
47.0	123	54.0	89.0	83.0
50.0	124	55.0	90.0	83.0
51.0	125	55.0	90.0	84.0
52.0	126	55.0	91.0	84.0
52.0	126	55.0	90.0	84.0
50.50	124.78	54.89	90.00	83.50

Receiver Pressure psig	Suction Pressure psig	Discharge Pressure psig	Water Cooled #/hr	Cond Water #/hr	Comp Speed rpm	Watt Meter rpm
110	38	125	2181	2070	447	54

Table IIIb THERMOSTATIC EXPANSION VALVE
65% Running Time
4-27-51

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
			57	57
50	52	88	54	54
58	61	77	59	58
50	52	88	54	54
51	58	77	57	56
51	53	89	56	56
50	56	79	57	56
52	53	88	56	55
50	52	85	55	55
53	53	88	56	55
50	52	85	55	55
53	53	87	55	55
57	61	76	59	57
50	52	88	54	54
58	60	75	59	57
50	52	87	54	53
58	52	85	57	57
50	52	87	53	52
61	52	84	56	56
50	51	86	53	53
57	60	75	59	57
50	52	85	54	54
56	52	85	56	56
50	58	76	57	57
50	51	85	54	54
58	52	84	56	55
55	60	75	59	57
50	58	77	58	58
50	52	85	55	54
54	51	85	55	55
59	62	75	60	58
50	56	76	57	56
51	53	84	55	55
60	52	85	57	57
51	53	89	55	54
61	60	82	57	56
50	52	86	54	54
52	52	84	56	56

Table IIIb - cont.

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
59	62	80	58	58
51	59	75	58	57
50	55	76	57	56
51	52	84	54	53
59	61	75	60	57
53.24	54.81	82.43	56.21	55.56

Table IIIc THERMOSTATIC EXPANSION VALVE
65% Running Time
4-27-51

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
56	124	70	93	
57	122	69	93	91
57	124	69	92	87
55	124	69	92	91
62	122	72	91	89
56	125	70	93	92
66	121	75	91	90
56	125	70	93	91
65	114	86	93	90
56	124	70	93	85
64	115	70	91	89
55	123	70	92	85
56	123	70	93	87
56	122	69	92	90
57	123	70	91	86
61	117	69	91	90
56	124	70	92	84
62	116	70	91	89
55	123	69	92	84
57	121	69	91	89
57	122	69	92	85
62	115	69	91	90
55	123	69	92	84
59	122	70	91	89
61	115	69	91	91
55	123	69	91	83
57	122	70	92	88
60	122	70	92	90
62	116	70	91	91
55	122	69	91	84
57	123	70	93	86
63	122	70	91	91
63	116	70	92	91
56	123	69	92	85
61	117	69	91	89
56	123	70	92	84
64	114	69	91	90
56	120	70	91	85

THERMOSTATIC EXPANSION VALVE
2-15-51
11:30 to 5:30
54% Running Time

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
	53*	77	57	57
47*			59	58
50*	49*	83	55	55
58	60	66	59	58
50*	50*	83	56	55
57*				
60	54	79	58	58
60*	51*	72	57	57
48	49	70	56	56
62*	51*	77	56	56
48		67	57	56
50*	55*	67	58	57
50	59	65	58	57
49*	48*	83	55	55
51	47	80	56	56
56	59	66	58	58
56	60*	67	59	59
49*	58*	69	59	58
48	54	68	57	57
60*	62*	74	57	57
55*	59*	64	58	58
54*	60	67	59	57
49*	58	69	58	58
52*	50*	78	56	56
48	56	68	57	56
50*	49*	79	56	56
59*	60*	74	58	58
50*	49*	76	56	57
59*	57*	75	57	57
59*	60*	76	58	58
56*	60*	67	59	58
58*	50*	80	57	57
48*	57	66	57	57
50*	48*	78	55	55
56*	59*	66	57	57
50*	44	80	55	55
56*	59*	65	58	57

Table IIId - cont.

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
49*	45*	83	56	56
51.81	54.26	72.88	57.13	56.83
53.48*	54.04*			

* Temperature of freon when compressor is running.

Table IIIe THERMOSTATIC EXPANSION VALVE
2-15-51
11:30 to 5:30
54% Running Time

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
48*	114*	51	87	
46	114	54	88	83*
53*	114*	52	87	87
43	114	53	88	80*
57*	112*	52	87	87*
66	120		86	79*
56*	111*	52	88	81
52*	117*	52	88	80*
62*	108*	54	88	83
51	117	53	88	78*
61*	113*	55	87	83
55	115	54	89	86*
55*	115*	54	89	86
62	108	55	86	87*
52*	120*	53	88	84
59	116	56	88	82*
53*	118*	54	87	84
55	118	54	89	83*
59*	116*	55	88	85
52	118*	52	88	82*
57*	116*	56	88	83
53*	118*	53	88	85*
59*	112*	54	89	83*
52	119	53	88	83*
63	107	55	86	83
56	114	53	88	82*
60	116	54	88	80
52*	108*	53	87	87
54	113	52	88	77*
52*	117*	52	88	80*
60*	111*	52	89	82*
53*	117*	52	87	89
63*	115*	54	86	82*
52	119	52	87	86*
61*	116*	56	88	81
52	117	52	87	86*
62	116*	55	86	80*

Table IIIe - cont.

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
52	117	52	86	87*
55.53	114.89	53.38	87.58	83.14
55.9*	114.63*			82.61*

* Temperature of freon when compressor is running.

Table IIIf THERMOSTATIC EXPANSION VALVE
2-15-51
6:00 to 12:00
42% Running Time

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
53			52	56
50	47	87	55	55
60	60	86	57	57
58	60	70	59	58
49	52	73	57	56
52	50	86	56	56
60	60	86	58	58
57	59	68	59	58
50	49	75	57	57
62	50	87	57	57
58	60	70	59	58
48	56	70	57	56
50	58	83	55	55
61	52	87	57	57
57	59	69	59	58
59	57	70	57	56
51	47	91	56	56
60	60	80	58	58
59	57	66	59	58
49	52	70	57	56
56	48	81	57	57
59	60	69	59	59
56	47	83	57	57
56	61	76	58	58
56	59	70	58	57
50	49	83	55	55
61	54	86	57	57
56	59	71	58	58
50	54	72	57	56
55	50	89	56	56
58	59	69	59	59
49	57	70	57	56
51	49	90	56	56
60	60	75	58	57
54	58	70	57	56
50	49	90	55	55
60	43	90	57	57

Table IIIf - cont.

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
57	59	69	58	57
50	46	90	55	55
61	50	90	57	57
57	59	69	59	58
55.24	54.38	78.15	57.10	56.81

Table IIIg THERMOSTATIC EXPANSION VALVE
2-15-51
6:00 to 12:00
42% Running Time

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
64	117	56	87	84
60	109	54	87	86
52	117	54	89	78
56	117	57	92	82
62	109	56	88	86
60	110	54	89	79
52	116	53	89	79
60	117	57	90	82
62	109	55	88	88
53	115	53	88	78
52	118	54	90	80
65	111	56	87	84
60	109	54	87	89
52	116	53	88	79
56	117	55	90	80
65	108	56	88	86
59	114	54	89	89
57	113	53	89	79
57	117	57	92	80
62	108	55	87	88
56	115	53	88	78
62	111	55	90	80
61	111	56	90	79
52	119	54	89	87
62	117	57	88	84
61	110	55	88	89
52	119	57	89	78
58	117	57	81	84
62	109	56	88	88
56	115	54	89	78
52	118	55	89	80
64	106	56	87	85
59	112	55	89	82
52	119	55	90	79
64	116	56	88	84
60	111	55	89	88
52	117	55	89	79

Table IIIg - cont.

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
63	117	57	87	81
61	110	55	88	89
52	117	55	89	79
58	117	58	91	81
58.17	113.90	55.17	88.54	82.63

Table IIIh THERMOSTATIC EXPANSION VALVE

2-15-51

11:30 to 5:30

54% Running Time

Receiver Pressure psig	Suction Pressure psig	Discharge Pressure psig	Water Cooled #/hr	Cond Water #/hr	Comp Speed rpm	Watt Meter rpm
105	39	123	1810	2002	450	53

6:00 to 12:00

42% Running Time

Receiver Pressure psig	Suction Pressure psig	Discharge Pressure psig	Water Cooled #/hr	Cond Water #/hr	Comp Speed rpm	Watt Meter rpm
105	39	123	1150	2138	445	53

4-27-51

65% Running Time

Receiver Pressure psig	Suction Pressure psig	Discharge Pressure psig	Water Cooled #/hr	Cond Water #/hr	Comp Speed rpm	Watt Meter rpm
110	40	130	1410	3360	446	55

Table IIIi THERMOSTATIC EXPANSION VALVE

Running Time

2-15-51				4-27-51	
11:30 to 5:30		6:00 to 12:00			
On	Off	On	Off	On	Off
			2.74	9.80	5.00
8.00	6.67	4.30	6.65	12.80	5.00
7.62	7.72	4.30	5.48	12.00	4.60
3.24	3.24	4.89	5.77	11.80	4.60
3.62	10.39	3.23	4.45	11.00	4.80
10.48	5.72	3.91	6.65	7.80	4.00
8.58	5.34	4.30	6.75	10.00	4.60
8.39	6.67	4.50	5.28	8.60	4.20
10.96	6.29	5.58	7.04	11.00	5.80
3.24	4.19	4.01	8.61	12.80	4.80
3.05	4.38	4.60	5.87	6.60	4.40
11.44	6.86	4.11	5.48	8.00	4.40
7.24	4.96	4.89	5.67	7.00	4.40
3.05	3.24	3.23	7.43	6.40	4.00
3.05	3.81	4.30	6.26	4.80	3.00
4.77	3.72	4.50	5.87	6.20	4.00
7.81	5.81	.88	3.52	6.60	4.60
1.91	3.15	2.64	3.52	6.00	4.10
5.43	3.34	.88	1.96	6.00	9.00
4.77	3.72	5.48	6.16	11.20	5.00
.93	3.43	4.60	6.75	8.80	4.00
4.77	5.05	5.28	5.48	6.20	4.60
2.67	3.05	4.21	6.16	5.60	3.20
5.72	2.95	4.89	5.57	5.50	3.40
.86	1.91	5.09	6.45	8.40	5.30
8.67	5.53	4.60	5.87	6.80	4.20
5.72	4.77	5.20	6.06	8.60	5.20
.95	2.29	4.89	5.77	7.20	
4.00	7.15	5.38	6.85		
3.81	3.81	4.80	5.77	233.50	124.20
5.34	7.62	4.89	6.45		
.86	3.62	4.89	6.26	357.7 minutes	
7.62	5.15	4.99	6.65	total time	
8.39	6.19	4.89	6.26		
8.20	6.86	5.28	8.51		
6.10		3.23			
191.26	168.60	151.72	208.02		

359.86 minutes total time 359.74 minutes total time

Table IVa

AUTOMATIC EXPANSION VALVE
3-19-51
Full Capacity

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
44.0	52.5	83.0	53.5	55.0
44.0	52.7	82.0	54.0	56.0
44.0	52.7	81.5	54.0	56.0
44.0	52.5	81.5	54.0	55.0
44.0	52.7	82.0	54.0	56.0
44.0	52.7	82.0	54.0	55.0
44.0	52.7	82.0	53.5	55.0
44.0	52.64	82.0	53.85	55.43

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
54.0	130.0	55.0	90.0	82.5
54.5	130.5	56.0	90.0	82.5
54.5	131.0	56.0	91.0	82.7
54.0	131.0	55.0	89.0	81.5
54.5	130.0	56.0	89.0	81.5
54.5	130.0	55.0	88.0	81.5
54.5	130.0	56.0	90.0	81.5
54.36	130.36	55.57	89.57	81.96

Receiver Pressure psig	Suction Pressure psig	Discharge Pressure psig	Water Cooled #/hr	Cond Water #/hr	Comp Speed rpm	Watt Meter rpm
110	37	125	2275	2120	445	54

Table IVb AUTOMATIC EXPANSION VALVE
2-16-51
6:00 to 12:00
63% Running Time

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
45*	46*	70	54	54
62*	45*	75	57	57
46	50	77	55	55
61*	58*	75	57	57
46	50	79	54	54
61*	62*	74	57	57
46*	52*	80	54	54
60*	62*	70	58	58
46*	52*	81	55	55
59*	61*	66	58	58
45*	52*	81	55	55
58*	61*	66	58	58
47	52	81	55	55
59*	60*	66	58	58
46*	56*	81	55	55
58*	60*	65	58	58
46*	53*	80	56	56
53*	59*	66	57	57
46	61*	79	56	56
45*	54*	69	56	55
52	54*	76	56	56
46*	53*	77	55	55
62	56	76	57	57
46*	52*	79	54	54
61	61	74	57	57
46*	53*	79	54	54
61	61	75	57	57
46*	53*	81	55	55
59	61	65	58	58
46*	52*	81	55	55
57	60	67	58	57
46*	53*	80	55	55
49	60	66	57	57
46*	53*	78	55	55
45	57	67	57	57
49*	54*	77	56	56

Table IVb - cont.

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
46*	52	75	54	54
60*	53*	76	56	56
46*	53	79	54	54
61*	61*	75	57	57
51.63	55.38	74.63	56.00	55.95
51.25*	55.07*			

*Temperature of freon when compressor is running.

Table IVc AUTOMATIC EXPANSION VALVE
2-16-51
6:00 to 12:00
63% Running Time

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
61	117	53	87	80*
56*	128*	53	89	74*
62*	116*	54	88	81*
56*	127*	53	88	77*
60	118	53	88	81*
56*	127*	53	89	77
59	121	52	88	81*
57*	127*	53	89	78
57	123	52	89	81*
58*	127*	53	90	78*
56*	124*	52	89	80*
59*	127*	54	91	78*
56*	123*	53	88	80
58	127	53	89	79*
55*	124*	52	87	80
61	126	56	89	78*
57*	127*	53	88	87
66	118	55	86	80*
56*	127*	53	88	81
64	114	54	86	80*
56*	127*	53	80	77
53	115	53	87	80*
56*	126*	53	88	76
61	117	53	87	80*
56*	127*	53	89	77
60	120	53	88	80*
56*	127*	53	89	77
56*	123*	53	88	80*
59	127*	53	90	78
56*	127*	53	88	80*
61	126*	55	91	79
55*	127*	53	88	81*
64	123*	55	87	80*
55*	127*	53	88	81*
65*	114*	55	87	80*
55*	127*	53	90	78*

Table IVc - cont.

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
62*	117*	54	87	81*
56*	127*	53	88	77*
61*	119*	53	88	80*
57*	127*	53	88	78*
58.25	123.45	53.28	88.28	79.13
57.15*	124.89*			79.42*

*Temperature of freon when compressor is running.

Table IVd AUTOMATIC EXPANSION VALVE
2-16-51
11:30 to 5:30
35% Running Time

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
50	51	88	55	55
57	59	68	57	56
45	52	72	55	55
49	51	86	54	54
59	59	68	58	48
49	58	67	57	56
60	58	74	57	57
56	59	65	57	56
60	52	83	57	57
54	58	70	57	56
59	51	87	55	55
50				
61	59	63	60	60
45	49	90	54	54
60	60	68	59	59
54	59	70	59	58
45	59	75	56	56
60	60	68	59	58
57	59	66	59	58
50	51	86	56	56
60	61	69	59	58
57	60	67	58	58
49	51	85	56	56
60	60	69	60	59
55	60	67	58	57
52	51	87	56	56
59	60	67	60	60
49				
61	58	83	58	57
59	58	68	59	58
45	53	70	57	57
61	51	75	57	57

Table IVd - cont.

Freon 12 Into Evap °F	Freon 12 Out of Evap °F	Water Into Evap °F	Water Out of Evap °F	Water In Box °F
59	60	79	59	58
46	50	90	55	55
61	60	68	59	59
52	59	69	58	57
52	52	90	57	56
54.51	54.80	74.77	57.34	56.63

Table IVe AUTOMATIC EXPANSION VALVE
2-16-51
11:30 to 5:30
35% Running Time

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
53	123	53	88	80
58	123	56	89	79
61	110	54	86	82
57	118	52	89	78
54	124	53	89	79
63	108	53	85	81
53	123	52	87	73
65	105	54	85	79
52	123	53	88	71
63	107	56	86	82
59	115	54	88	77
				76
58	122	54	70	
60	114	54	89	82
58	123	55	91	76
58	124	55	92	83
62	112	54	88	82
55	123	53	89	76
67	106	55	87	80
59	117	53	89	76
55	125	53	89	79
66	106	56	87	80
61	115	54	78	81
57	124	53	90	76
66	106	55	86	82
59	116	53	88	74
58	123	56	92	78
				82
63	110		88	
56	121	54	89	75
61	122	56	88	79
63	110	54	87	82

Table IVe - cont.

Freon 12 Into Comp °F	Freon 12 Out of Comp °F	Water Into Cond °F	Water Out of Cond °F	Receiver Temp °F
55	121	53	89	76
61	123	57	88	79
60	115	54	89	83
55	125	54	89	77
64	109	56	87	82
57	121	54	89	78
59.22	117.00	54.14	87.44	78.75

Table IVf AUTOMATIC EXPANSION VALVE

2-16-51

11:30 to 5:30

35% Running Time

Receiver Pressure psig	Suction Pressure psig	Discharge Pressure psig	Water Cooled #/hr	Cond Water #/hr	Comp Speed rpm	Watt Meter rpm
105	38	128	1140	1985	444	55

6:00 to 12:00

63% Running Time

Receiver Pressure psig	Suction Pressure psig	Discharge Pressure psig	Water Cooled #/hr	Cond Water #/hr	Comp Speed rpm	Watt Meter rpm
108	38	128	1920	1992	450	54

Table IVg AUTOMATIC EXPANSION VALVE

COMPRESSOR RUNNING TIME

11:30 to 5:30 2-16-51 6:00 to 12:00

On Minutes	Off Minutes
	.77
6.12	6.70
4.21	5.36
4.59	6.12
4.69	9.57
6.32	7.08
3.83	7.08
3.25	4.79
3.06	12.25
6.32	8.61
2.87	4.60
4.40	8.42
3.45	8.61
3.83	7.85
3.25	8.13
3.92	8.42
3.83	9.57
3.54	8.23
4.40	8.23
3.83	9.57
3.83	7.66
4.59	6.99
5.74	7.56
4.40	6.70
5.07	6.51
4.59	6.70
4.21	6.60
4.50	
128.99	221.36

Total time 350.35 minutes

On Minutes	Off Minutes
1.71	5.70
8.72	5.88
9.49	5.79
9.49	5.79
9.87	5.70
9.30	5.88
8.64	6.07
9.49	6.45
10.25	6.45
10.82	5.88
10.25	6.26
10.06	6.26
9.68	6.26
11.01	5.98
10.63	5.70
10.44	6.07
11.01	5.70
10.44	5.70
10.44	5.50
11.01	5.88
11.20	5.70
10.82	5.98
4.94	
219.71	136.84

Total time 356.55 minutes

APPENDIX II

CALCULATIONS

HIGHSIDE FLOAT VALVE

Full Capacity:

Refrigeration Effect =

(Wt. of Water) (Specific Heat) (Change in Temperature) =

(2460) (1) (80.42-54.29) = 63,600 Btu/hr

Power Input to Motor =

(Wattmeter rpm) (Meter Constant) (60) /1,000 =

(55) (1.2) (60) = 3.96 KW-hr =

(3.96) (3413) = 13,515 Btu/hr

Coefficient of Performance =

$$\frac{\text{Refrigeration Effect}}{\text{Power Required to Obtain Ref. Eff.}} =$$

$$\frac{63,600}{13,515} = 4.7$$

Heat to Condenser Water =

(Weight of Water) (Specific Heat) (Change in Temp) =

(1802) (1) (90.91 - 49.52) = 74,603 Btu/hr

80% Running Time:

Refrigeration Effect =

(1750) (80.04 - 56.95) = (23.09) (1750) = 40,425 Btu/hr

plus (430) (3) (4) = 10,320 Btu/hr (Box Temp. Variation)

Total Effect 50,745 Btu/hr

Power to Motor =

(55) (1.2) (60) (.80) /1000 = 3.17 KW-hr = 10,810 Btu/hr

Coefficient of Performance = $\frac{50,745}{10,810}$ = 4.68

Heat to Condenser Water =

(1760) (92.54 - 54.11) (.80) = 54,100 Btu/hr

45% Running Time:

Refrigeration Effect =

(1065) (79.84 - 58.36) = 22,897 Btu/hr

Plus (5) (430) (3) = 7,740 Btu/hr

Total Effect 30,637 Btu/hr

Power to Motor =

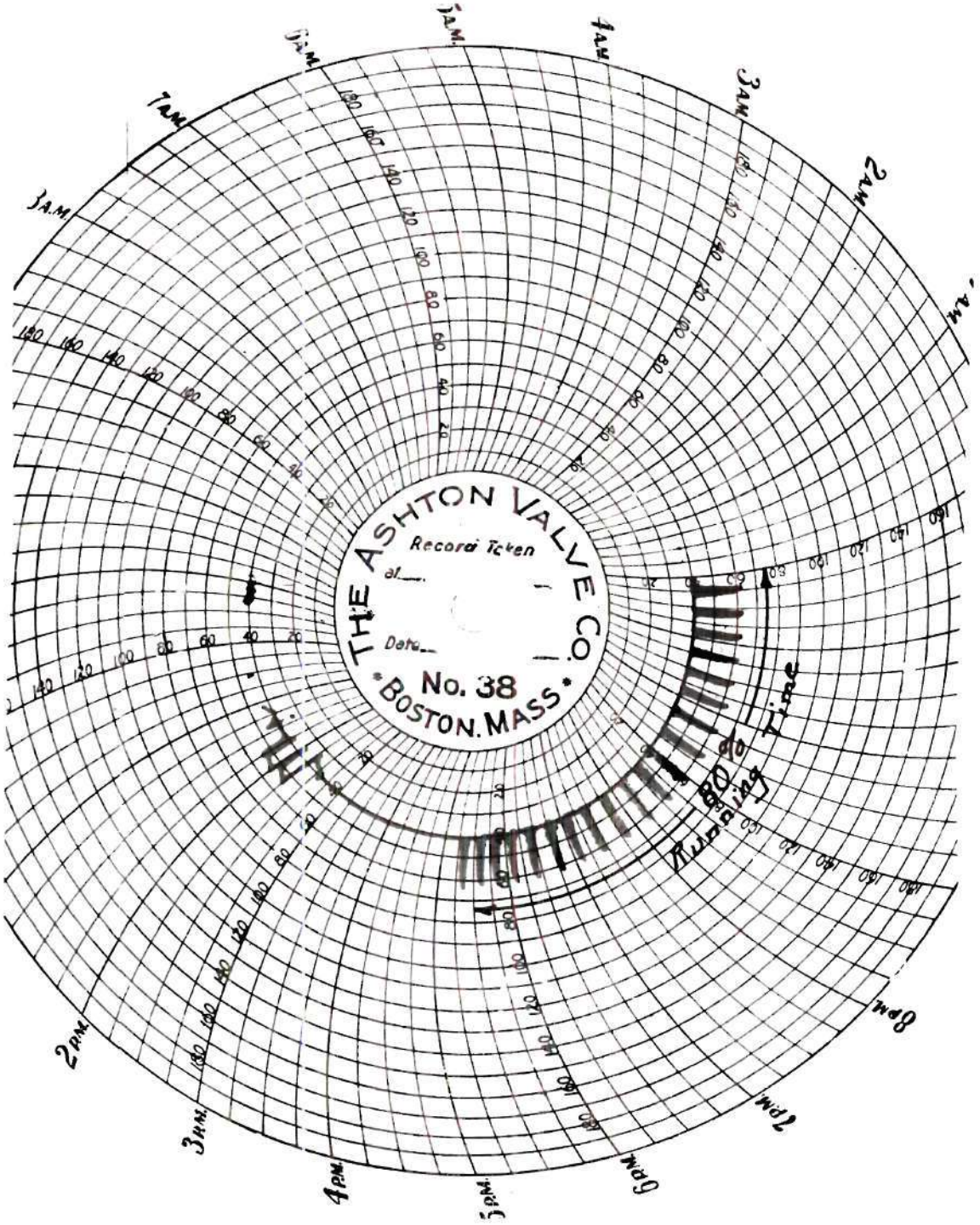
(55) (1.2) (60) (.45) = 1.78 KW-hr = 6,090 Btu/hr

Coefficient of Performance = $\frac{30,637}{6,090}$ = 5.04

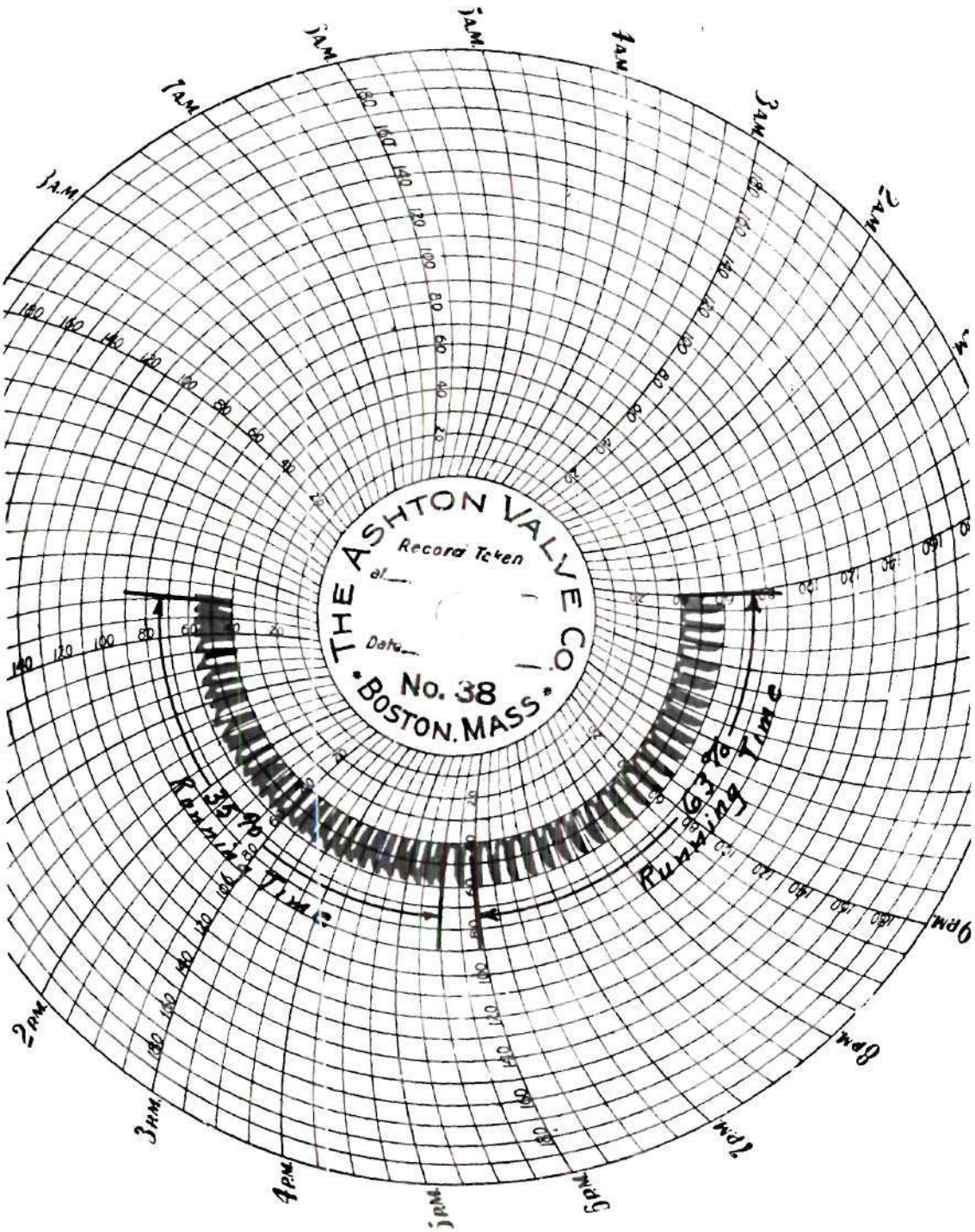
Heat to Condenser Water =

(1720) (37.94) (.45) = 29,300 Btu/hr

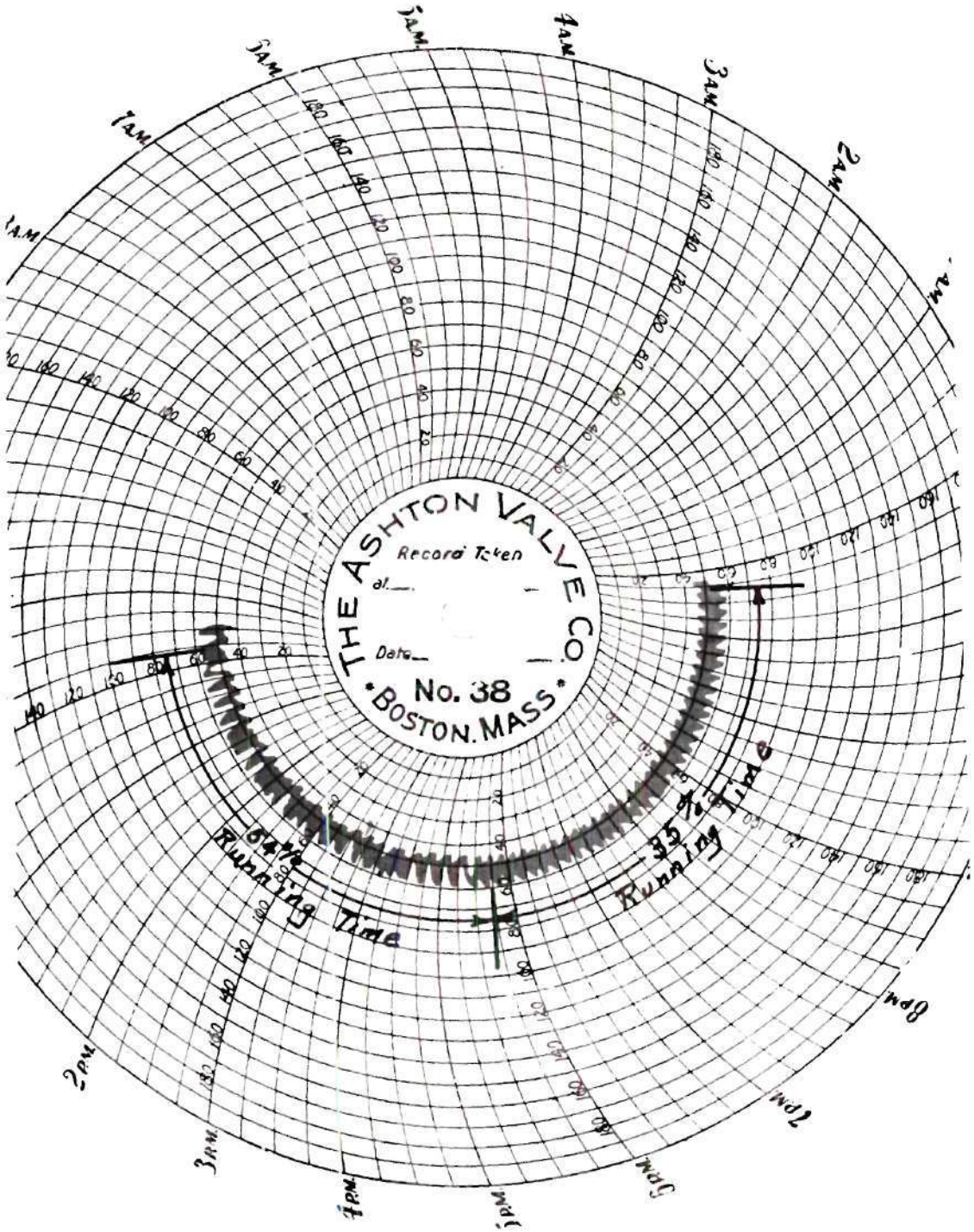
APPENDIX III



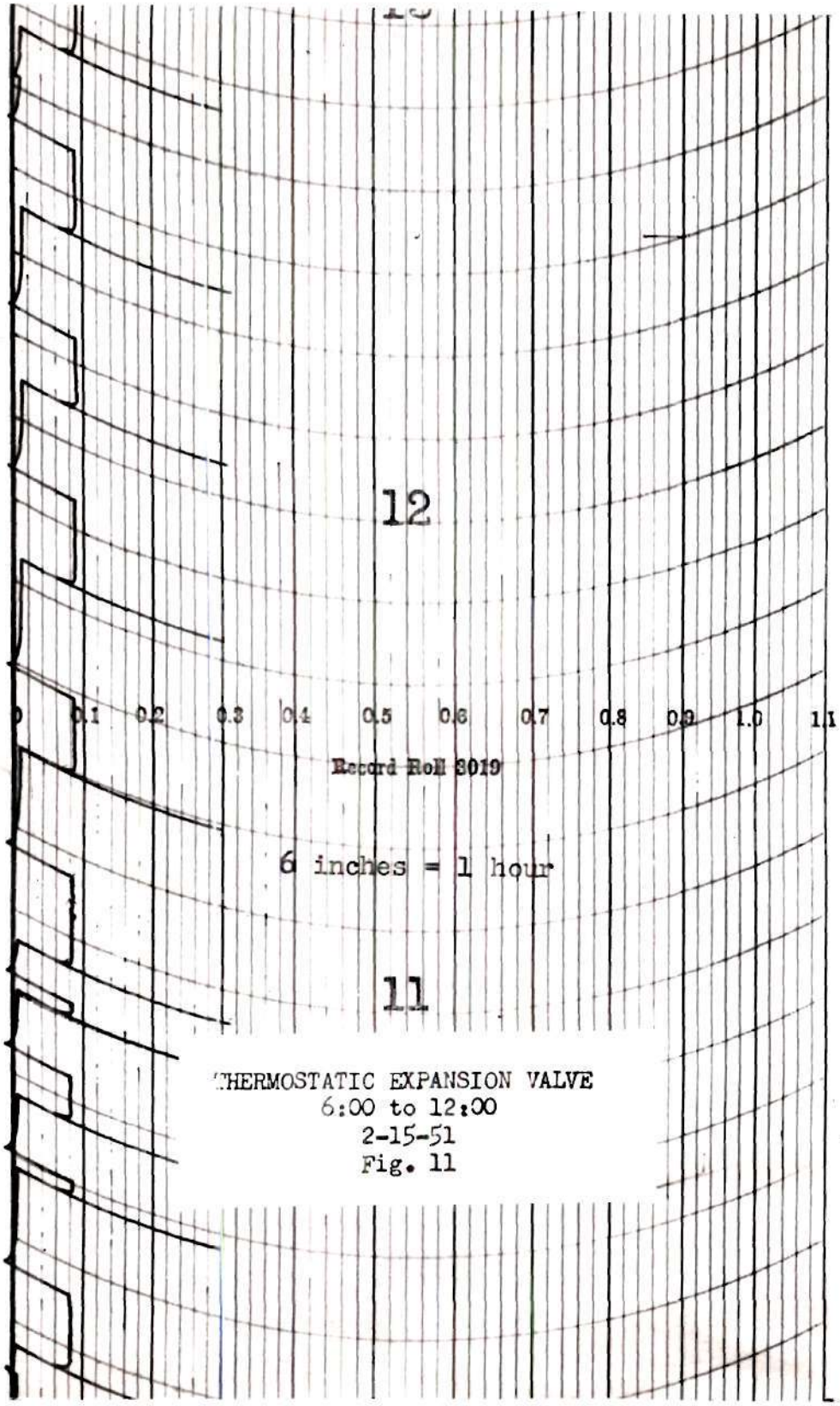
HIGHSIDE FLOAT VALVE
1-26-51
Fig. 8



AUTOMATIC EXPANSION VALVE
2-16-51
Fig. 9



THERMOSTATIC EXPANSION VALVE
2-15-51
Fig. 10



THERMOSTATIC EXPANSION VALVE
6:00 to 12:00
2-15-51
Fig. 11

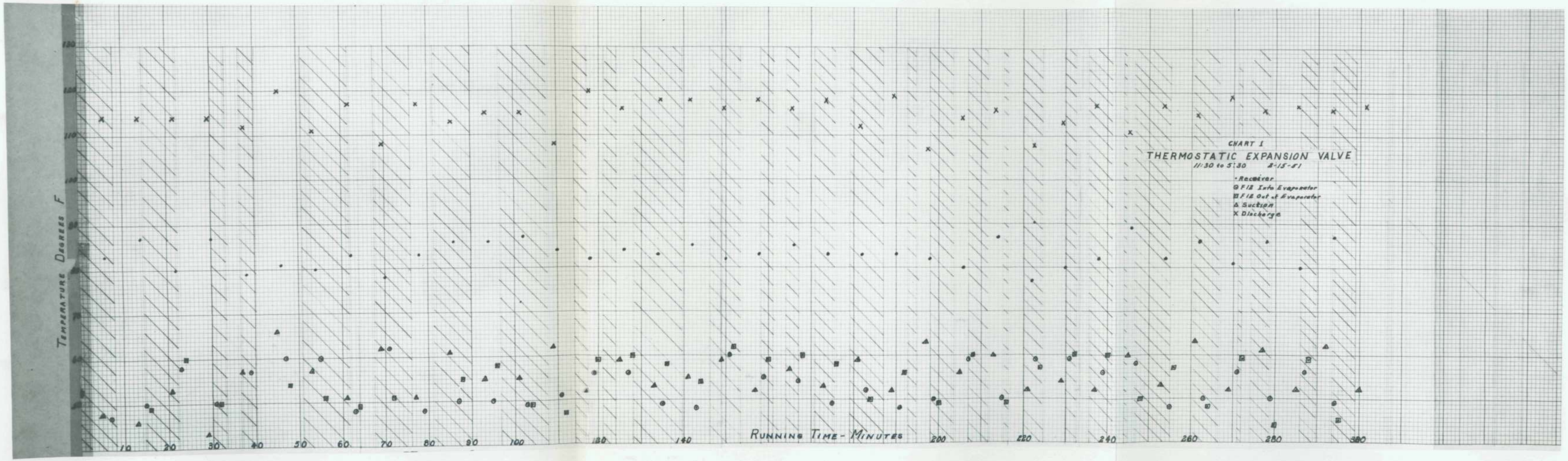


CHART 1
THERMOSTATIC EXPANSION VALVE
11:30 to 5:30 2-15-51
• Receiver
⊙ F12 Into Evaporator
⊞ F12 Out of Evaporator
△ Suction
X Discharge
TEMPERATURE DEGREES F
RUNNING TIME - MINUTES
10
20
30
40
50
60
70
80
90
100
120
140
200
220
240
260
280
300

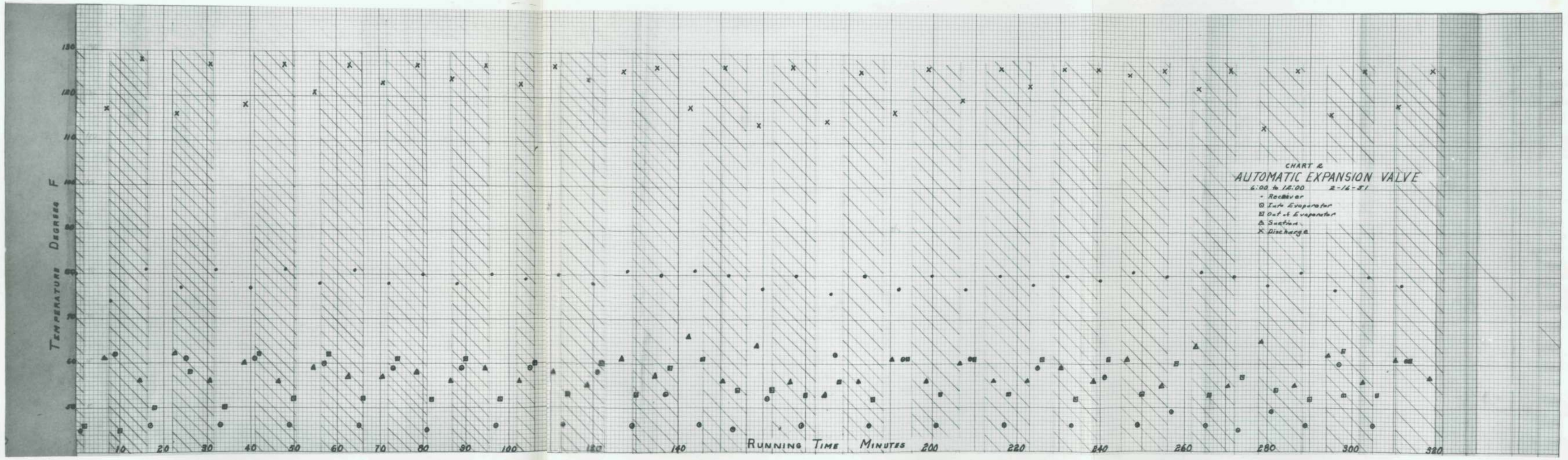


CHART 2
AUTOMATIC EXPANSION VALVE
6:00 to 12:00 2-16-31
• Receiver
□ Into Evaporator
▣ Out of Evaporator
△ Suction
X Discharge
TEMPERATURE DEGREES F
RUNNING TIME MINUTES
10
20
30
40
50
60
70
80
90
100
120
140
200
220
240
260
280
300
320

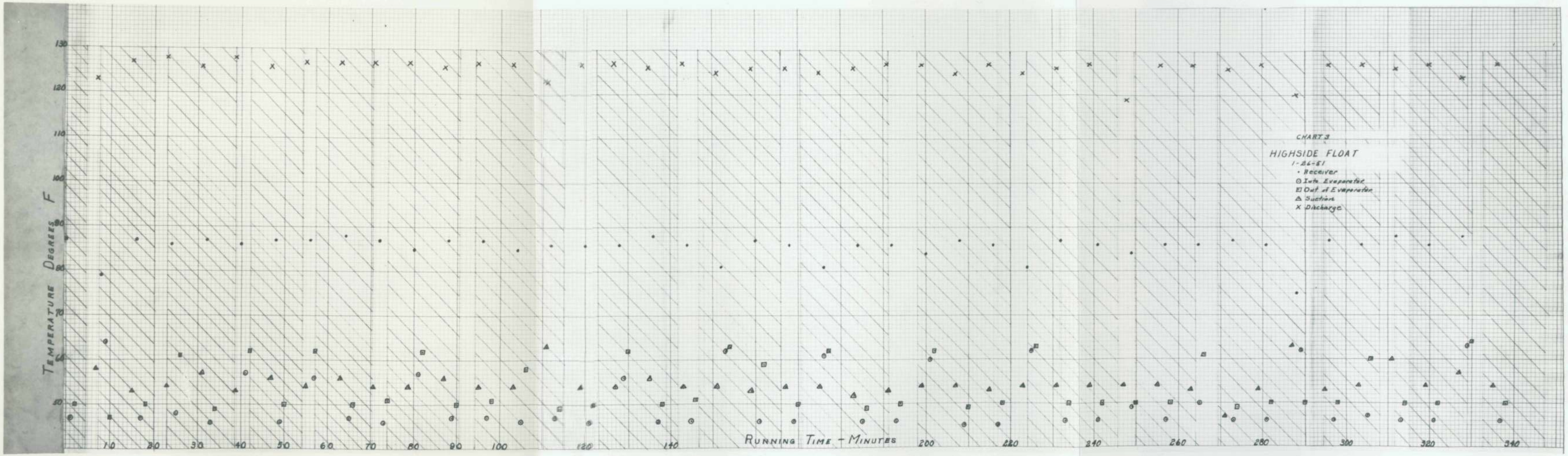


CHART 3
HIGHSIDE FLOAT
1-26-51
• Receiver
⊙ Into Evaporator
⊡ Out of Evaporator
△ Suction
X Discharge
TEMPERATURE DEGREES F
130
120
110
100
90
80
70
60
50
10
20
30
40
50
60
70
80
90
100
120
140
RUNNING TIME - MINUTES
200
220
240
260
280
300
320
340